(12) UK Patent Application (19) GB (11) 2 268 694 (13) A

(43) Date of A Publication 19.01.1994

(21) Application No 9214879.0

(22) Date of Filing 14.07.1992

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(51) INT CL^5
F23R 3/40, F02C 7/26, F23R 3/36

(52) UK CL (Edition M)
B1F FD2A

(56) Documents Cited
GB 1577256 A GB 1547810 A

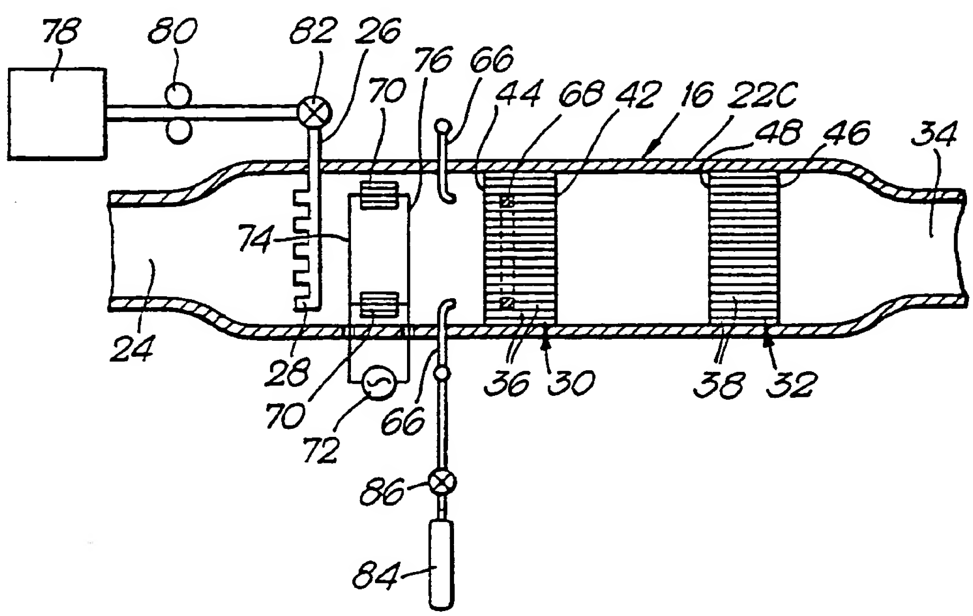
(58) Field of Search
UK CL (Edition L) B1F
INT CL^5 F02C, F23R
ONLINE DATABASES: WPI, CLAIMS

3

(54) A catalytic combustion chamber

(57) A gas turbine catalytic combustion chamber (22A) comprises a first catalyst coated ceramic honeycomb monolith (30) which forms a first catalytic combustion zone. A hydrocarbon fuel supplied from fuel injectors (28) is burnt in air supplied from inlet (24) in the first catalytic combustion zone. A plurality of injectors (66) inject hydrogen onto a plurality of regions of the first catalyst coated ceramic honeycomb monolith (30). The hydrogen has greater activity than the hydrocarbon at ambient temperatures, and the hydrogen burns in the catalytic combustion zone and increases the surface temperature of the catalyst to a temperature in the region of 350°C to 400°C. The catalytic combustion of the hydrocarbon fuel in the first catalytic combustion zone occurs at this temperature, and once it has been reached the process can continue on its own and the hydrogen supply is switched off.

Fig. 2.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.

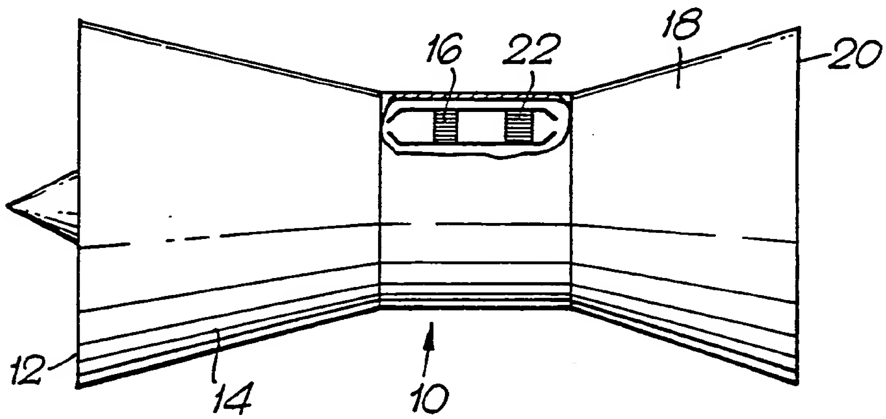
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Fig. 2.

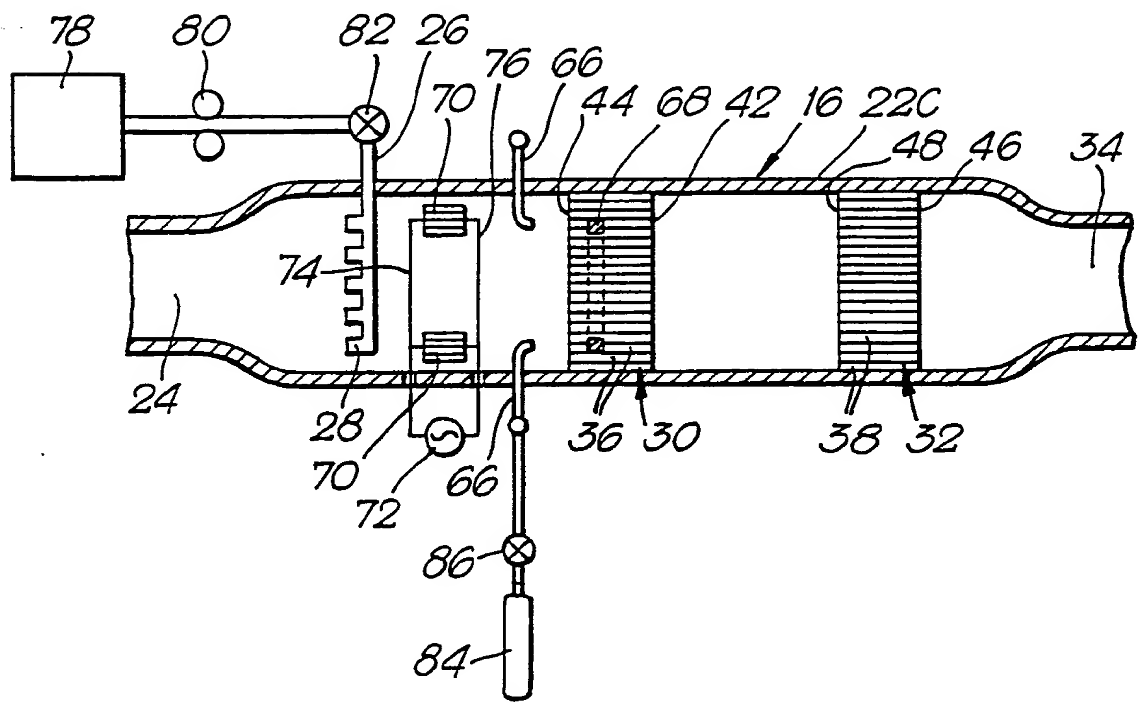
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Fig. 3.

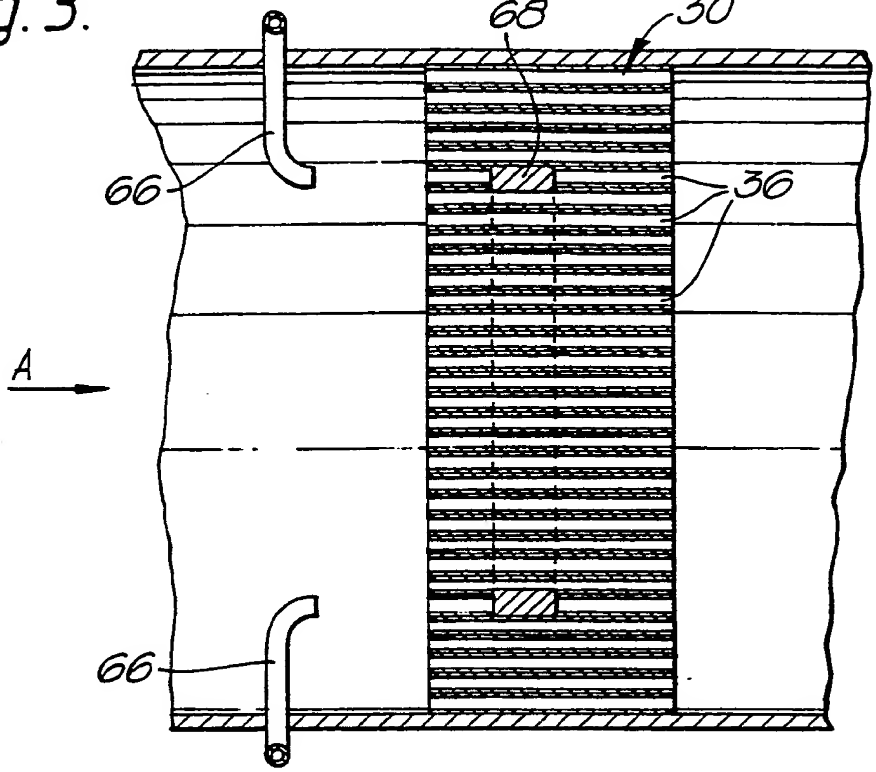
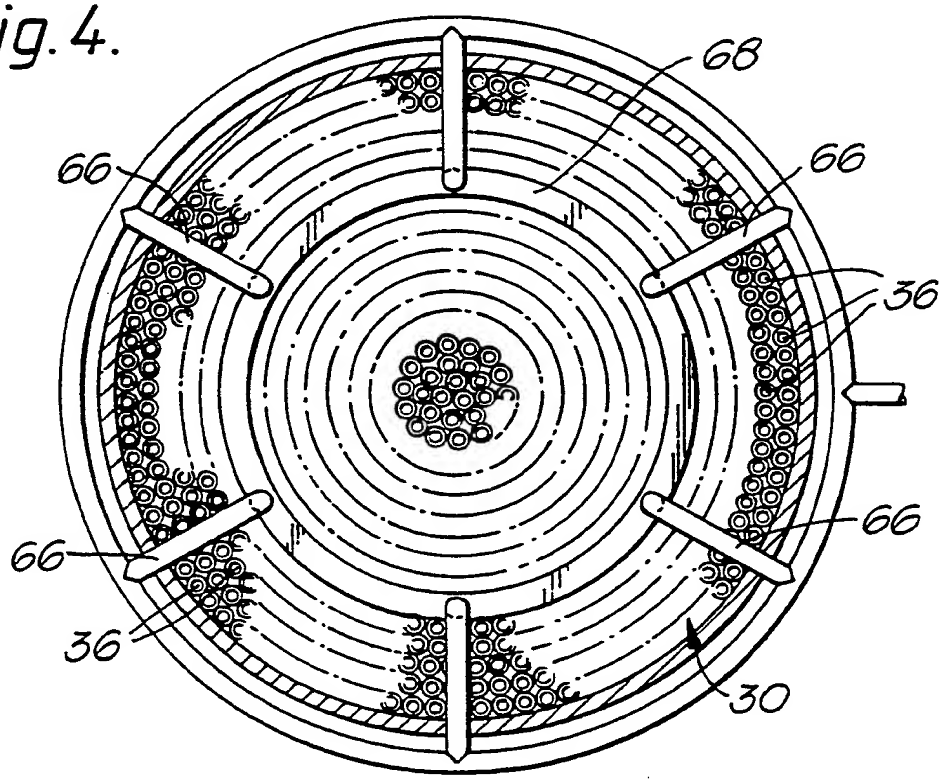


Fig. 4.



A GAS TURBINE COMBUSTION CHAMBER

The present invention relates to gas turbine combustion chambers, and is particularly concerned with catalytic combustion chambers for gas turbine engines.

The use of catalytic combustion chambers in gas turbine engines is a desirable aim, because of the benefits in the reductions of combustion chamber emissions, particularly nitrogen oxides (NOx). The reduction in NOx is due to the lower operating temperatures. In catalytic combustion chambers it is known to use ceramic honeycomb monoliths which are coated with a suitable catalyst. It is also known to arrange several of the ceramic honeycomb monoliths in flow series such that there is a progressive reduction in the cross-sectional area of the cells from one ceramic honeycomb monolith to an adjacent ceramic honeycomb monolith, in the direction of flow. The smaller cross-sectional area cells have the benefit of reducing emissions of unburned hydrocarbons.

In catalytic combustion chambers hydrocarbon fuel and air are mixed and supplied to the catalyst coated ceramic honeycomb monoliths. The hydrocarbon fuel and air mixture diffuses to the catalyst coated surfaces of the ceramic honeycomb monoliths and reacts on the active sites, at and within, the surface. Using existing catalysts the catalytic combustion of hydrocarbon fuels at room, or ambient, temperature does not occur. In order for the catalytic combustion of hydrocarbon fuels to occur the surface temperature of the catalyst must be in the range of 350°C to 400°C or greater. To start the catalytic combustion of the hydrocarbon fuels the surface temperature of the catalyst coated ceramic honeycomb monolith has to be increased to a temperature in the range 350°C to 400°C or greater.

Prior art methods of increasing the temperature of the catalyst coated ceramic honeycomb monolith have used a conventional pilot combustion chamber. The conventional

pilot combustion chamber burns hydrocarbon fuels in the conventional manner and supplies the hot combustion product gases to the catalytic combustion chamber to increase the surface temperature of the catalyst coated ceramic honeycomb monolith to about 350^{c}C to 400^{o}C. However, these pilot combustion chambers are undesirable because the produce emissions of NOx.

The present invention seeks to provide a catalytic combustion chamber which overcomes the above mentioned problems.

Accordingly the present invention provides a gas turbine combustion chamber comprising a catalytic combustion zone, means to supply a first fuel to the catalytic combustion zone, means to supply air to the catalytic combustion zone, means to supply a second fuel to the catalytic combustion zone, the second fuel not having a sufficiently high activity to burn in the catalytic combustion zone if the temperature of the catalytic combustion zone is below a predetermined temperature, the first fuel having a sufficiently high activity to burn in the catalytic combustion zone if the temperature of the catalytic combustion zone is below the predetermined temperature to increase the surface temperature of the catalyst to the predetermined temperature at which the second fuel will burn in the catalytic combustion zone.

Preferably the second fuel is a hydrocarbon, preferably a natural gas.

Preferably the first fuel is hydrogen, alternatively the first fuel may be hydrogen enriched natural gas.

Preferably the means to supply the first fuel comprises a plurality of injectors, each injector supplies the first fuel to a region of the catalytic combustion zone.

Preferably at least one heat conducting member is arranged within the catalytic combustion zone to interconnect at least two of the regions supplied with

the second fuel.

Preferably the heat conducting member interconnects all the regions, the heat conducting member may form a loop and preferably the loop is annular.

The catalytic combustion chamber may be tubular or annular.

Preferably at least one electrical resistance heater is arranged upstream of the catalytic combustion zone, the electrical resistance heater is connected to an electrical power supply.

Preferably a plurality of electrical resistance heaters are arranged upstream of the catalytic combustion zone, the electrical resistance heaters are connected to an electrical power supply, each electrical resistance heater is arranged upstream of a respective one of the regions supplied with the first fuel.

The present invention also provides a method of operating a gas turbine engine combustion chamber having a catalytic combustion zone, the method comprising supplying a first fuel having a sufficiently high activity to burn at ambient temperature in the catalytic combustion zone to the catalytic combustion zone from the start of operation of the gas turbine engine until a predetermined temperature level is obtained in the catalytic combustion zone, burning the first fuel in the catalytic combustion zone to increase the surface temperature of the catalyst to the predetermined temperature, supplying a second fuel not having a sufficiently high activity to burn at ambient temperature in the catalytic combustion zone to the catalytic combustion zone when the surface temperature of the catalyst is at least equal to the predetermined temperature, burning the second fuel in the catalytic combustion zone and terminating the supply of first fuel to the catalytic combustion zone.

The present invention will be more fully described by way of example, with reference to the accompanying

drawings in which:

Figure 1 is a partially cut-away view of a gas turbine engine having a catalytic combustion chamber according to the present invention.

Figure 2 is a cross-sectional view through a first embodiment of the catalytic combustion chamber shown in Figure 1.

Figure 3 is a view of part of figure 2 to an enlarged scale.

Figure 4 is a view in the direction of arrow A in figure 3.

A gas turbine engine 10, which is shown in Figure 1, comprises in flow series an intake 12, a compressor section 14, a combustion section 16, a turbine section 18 and an exhaust 20. The gas turbine engine 10 operates conventionally in that air is compressed as it flows through the compressor section 14, and fuel is injected into the combustor section 16 and is burnt in the compressed air to provide hot gases which flow through and drive the turbines in the turbine section 18. The turbines in the turbine section 18 are arranged to drive the compressors in the compressor section 14 via shafts (not shown).

The combustion section 16 comprises one or more catalytic combustion chambers 22 as shown more clearly in Figures 2, 3 and 4. The catalytic combustion chamber 22 has an inlet 24 at its upstream end for the supply of compressed air, from the compressor section 14, into the catalytic combustion chamber 22, and a fuel pipe 26 and fuel injectors 28, for the supply of a hydrocarbon fuel into the upstream end of the catalytic combustion chamber 22. The hydrocarbon fuel injectors 28 are arranged to be supplied with hydrocarbon fuel in a controlled manner from a supply of hydrocarbon fuel 78 via a pump 80 and a valve 82.

A first catalyst coated ceramic honeycomb monolith 30, positioned downstream of the fuel injectors, forms a first catalytic combustion zone. A second catalyst

coated ceramic honeycomb monolith 32, positioned downstream of the first catalyst coated ceramic honeycomb monolith 30, forms a second catalytic combustion zone.

The catalytic combustion chamber 22 has an outlet 34 at its downstream end, for discharging the hot gases produced in the combustion process to the turbine section 18.

The first catalyst coated ceramic honeycomb monolith 30 has a plurality of cells 36 which extend therethrough. The second catalyst coated ceramic honeycomb monolith 32 has a plurality of cells 38 which extend therethrough. The cross-sectional area of individual cells 36 in the first honeycomb monolith 30 is greater than the cross-sectional area of the individual cells 38 in the second honeycomb monolith 32.

In order to start the catalytic combustion process it is necessary to raise the temperature of the first catalyst coated ceramic honeycomb monolith to a temperature of 350-400°C or greater. The catalytic combustion chamber 22 has a plurality of hydrogen injectors 66 which are used to start the catalytic combustion process in the catalytic combustion chamber 22. The hydrogen injectors 66 are arranged to be supplied with hydrogen in a controlled manner from a supply of hydrogen 84 <u>via</u> a valve 86. The supply of hydrogen 84 may be a gas bottle containing hydrogen. The hydrogen injectors 66 inject hydrogen onto a number of regions of the first catalyst coated ceramic honeycomb monolith 30. The hydrogen has a greater activity than the hydrocarbon fuel, for example natural gas, at room, or ambient, temperature and the hydrogen is burned in the first catalytic combustion zone at room temperature to raise the temperature of the first catalyst coated ceramic honeycomb monolith 30 to a temperature of 350 to 400°C or greater. At this temperature the hydrocarbon fuel, for example natural gas, is injected into the first catalyst coated ceramic honeycomb monolith and is burned

in the first catalytic combustion zone and the supply of hydrogen to the hydrogen injectors 66 is terminated.

It may be possible to use other fuels which have a sufficiently high activity to burn at ambient temperatures in the catalytic combustion zone to heat the surface of the catalyst coated ceramic honeycomb monolith. As an example the injectors 66 may inject hydrogen enriched natural gas into the catalytic combustion zone.

In order to produce a more uniform temperature throughout the first catalyst coated ceramic honeycomb monolith 30 during the starting procedure, one or more heat conducting members 68 are arranged within the first catalyst coated ceramic honeycomb monolith 30 to interconnect the regions supplied with hydrogen. The heat conducting members 68 preferably are formed into an annular ring.

Also a plurality of electrical resistance heaters 70 are positioned in the catalytic combustion chamber 22 upstream of the first catalyst coated ceramic honeycomb monolith 30. Each electrical resistance heater 70 is arranged immediately upstream of one of the regions supplied with hydrogen by an injector 66. The electrical resistance heaters 70 are connected in parallel to a power supply 72 by first and second electrical connectors 74 and 76. The electrical resistance heaters 70 increase the temperature of air during the starting procedure to aid the catalytic combustion process at ambient temperatures.

In normal operation of the gas turbine engine the compressor 14 delivers air to the catalytic combustion chambers 22 at a high enough temperature for example between 350 and 600^{o}C.

The present invention has been described with reference to a tubular catalytic combustion chamber. However, it is equally possible to apply the invention to an annular catalytic combustion chamber. In an annular

catalytic combustion chamber the heat conducting members are preferably annular rings which interconnect the regions supplied with hydrogen.

The present invention has been described with reference to catalyst coated ceramic honeycomb monoliths. However, it is possible to use a catalyst coated metallic matrix, for example a metallic matrix comprising one or more corrugated metal strips interleaved with one or more smooth metal strips which are wound into a spiral or are arranged concentrically. A suitable metal for forming the metallic matrix is an iron-chromium-aluminium alloy which may contain yttrium for example Fecralloy (Registered Trade Mark). The catalyst may be platinum or 10% rhodium -platinum.

Claims:-

1. A gas turbine combustion chamber comprising a catalytic combustion zone, means to supply a first fuel to the catalytic combustion zone, means to supply air to the catalytic combustion zone, means to supply a second fuel to the catalytic combustion zone, the second fuel not having a sufficiently high activity to burn in the catalytic combustion zone if the temperature of the catalytic combustion zone is below a predetermined temperature, the first fuel having a sufficiently high activity to burn in the catalytic combustion zone if the temperature of the catalytic combustion zone is below the predetermined temperature to increase the surface temperature of the catalyst to the predetermined temperature at which the second fuel will burn in the catalytic combustion zone.

2. A gas turbine combustion chamber as claimed in claim 1 in which the second fuel is a hydrocarbon.

3. A gas turbine combustion chamber as claimed in claim 2 in which the hydrocarbon is a natural gas.

4. A gas turbine combustion chamber as claimed in any of claims 1 to 3 in which the first fuel is hydrogen.

5. A gas turbine combustion chamber as claimed in any of claims 1 to 3 in which the first fuel is hydrogen enriched natural gas.

6. A gas turbine combustion chamber as claimed in any of claims 1 to 5 in which the means to supply the first fuel comprises a plurality of injectors, each injector supplies the first fuel to a region of the catalytic combustion zone.

7. A gas turbine combustion chamber as claimed in claim 6 in which at least one heat conducting member is arranged within the catalytic combustion zone to interconnect at least two of the regions supplied with the second fuel.

8. A gas turbine combustion chamber as claimed in claim 7 in which the heat conducting member interconnects all the regions.

9. A gas turbine combustion chamber as claimed in claim 8 in which the heat conducting member forms a loop.

10. A gas turbine combustion chamber as claimed in claim 9 in which the loop is annular.

11. A gas turbine combustion chamber as claimed in any of claims 1 to 10 in which the catalytic combustion chamber is tubular.

12. A gas turbine combustion chamber as claimed in any of claims 1 to 10 in which the catalytic combustion chamber is annular.

13. A gas turbine combustion chamber as claimed in any of claims 1 to 12 in which at least one electrical resistance heater is arranged upstream of the catalytic combustion zone, the electrical resistance heater is connected to an electrical power supply.

14. A gas turbine combustion chamber as claimed in claim 6 in which a plurality of electrical resistance heaters are arranged upstream of the catalytic combustion zone, the electrical resistance heaters are connected to an electrical power supply, each electrical resistance heater is arranged upstream of a respective one of the regions supplied with first fuel.

15. A gas turbine combustion chamber substantially as hereinbefore described with reference to and shown in Figure 2 to 4 of the accompanying drawings.

16. A gas turbine engine comprising a catalytic combustion chamber as claimed in any of claims 1 to 15.

17. A method of operating a gas turbine engine combustion chamber having a catalytic combustion zone, the method comprising supplying a first fuel having a sufficiently high activity to burn at ambient temperature in the catalytic combustion zone to the catalytic combustion zone from the start of operation of the gas turbine engine until a predetermined temperature level is

obtained in the catalytic combustion zone, burning the first fuel in the catalytic combustion zone to increase the surface temperature of the catalyst to the predetermined temperature, supplying a second fuel not having a sufficiently high activity to burn at ambient temperature in the catalytic combustion zone to the catalytic combustion zone when the surface temperature of the catalyst is at least equal to the predetermined temperature, burning the second fuel in the catalytic combustion zone and terminating the supply of first fuel to the catalytic combustion zone.

18. A method as claimed in claim 17 in which the predetermined temperature is at least 350°C.

19. A method as claimed in claim 17 or claim 18 in which the second fuel is a hydrocarbon.

20. A method as claimed in claim 19 in which the hydrocarbon is a natural gas.

21. A method as claimed in any of claims 17 to 20 in which the first fuel is hydrogen.

22. A method as claimed in any of claims 17 to 20 in which the second fuel is hydrogen enriched natural gas.

23. A method of operating a gas turbine engine combustion chamber having a catalytic combustion chamber substantially as hereinbefore described with reference to figures 1 to 4 of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
GB 9214879.0

Relevant Technical fields

(i) UK Cl (Edition K) B1F

(ii) Int Cl (Edition 5) F02C F23R

Search Examiner

J H WARREN

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES: WPI AND CLAIMS

Date of Search

23.10.92

Documents considered relevant following a search in respect of claims 1-23

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 1577256 A (ENGELHARD) page 4 lines 5-89	
A	GB 1547810 A (COMSTOCK) figure 7 lines 60-115 page 7	

Category	Identity of document and relevant passages	Relevant to clairr

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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P: Document published on or after the declared priority date but before the filing date of the present application.

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